DJ Warren and Associates

Memo

To: Lewis River ACC Science Subgroup

From: Kevin Malone

cc: Mike Bonoff, Todd Olson

Date: February 13, 2017

Re: EDT Modeling In-Lieu Habitat Fund

EDT Modeling

This memo describes methods used to model in-lieu habitat actions using Ecosystem Diagnosis and Treatment (EDT) for the Lewis River. Modeling results are presented for the January 18, 2017, January 19, 2017 and February 2, 2017 EDT analyses[1].

An initial set of EDT model runs was developed for the January 18 and 19, 2017 meetings held at the WDFW Vancouver office and Merwin Dam, respectively. At the January 18, 2017 meeting, the ACC Science Subgroup asked that an additional set of model runs be completed that substituted (on a 1 to 1 kilometer basis) mainstem Lewis River habitat upstream of Swift Dam for tributary habitat initially modeled. Following the January 19, 2017 meeting, the subgroup requested EDT model runs be completed that:

1. Combined all tributary and mainstem Lewis River habitat restored to EDT Template conditions in the first two model runs, and
2. Restored as much stream habitat as possible based on the assumption that restoration costs will be $500,000 per mile and total monies available are $37.954 million.

The February 2, 2017 model runs incorporated an overall downstream survival (ODS) rate of 75 percent for all alternatives that included juvenile fish passage at Yale Dam. The 75 percent ODS is the target value required in the Settlement Agreement when downstream passage at Yale is available to the Services (Lewis River Settlement Agreement, Section 4.1.4(a)).

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[1] Comments received at the February 2, 2017 meeting have been incorporated into this memo.

Methods

The five passage alternatives modeled using EDT are shown in Table 1. A description of each alternative is presented in Appendix A. The values used for Overall Downstream Survival (ODS), Juvenile Collection Efficiency (CE), Adult Trap Efficiency (ATE), Upstream Passage Survival (UPS) and Stream Habitat Restored to Template (as defined in EDT) are presented in Table 2.

Table 1. The five passage alternatives modeled in EDT

	Option	Enhancement Funds*	Downstream Collector/Merwin	Downstream Collector/Yale	Upstream Collector/Yale	Upstream Collector/Swift	Adult Transport
1A1	Yale: D/S Only	**$25.303 million**	NO	YES	NO	NO	Adults into Yale
1A2	Yale: D/S Only	**$25.303 million**	NO	YES	NO	NO	No adults into Yale; Collect entrained juveniles from Swift
1B	Yale: D/S & U/S	**$18.997 million**	NO	YES	NO	YES	All adults into Yale & adults into Swift (volitionally only)
2	Yale & Merwin: U/S & D/S	**$0**	YES	YES	YES	YES	Move all adult fish into Merwin
3	Passage at Neither	**$37.954 million**	NO	NO	NO	NO	Move all adults into Swift (current scenario)

Selection of Streams for Restoration

January 18, 2017 EDT Model Run

For the January 18, 2017 EDT model run it was assumed that the maximum monies available for habitat restoration ($37.954 million) were sufficient to restore the following Swift area streams to EDT Template condition (Table 3):

1. Pine Creek
2. Swift Campground Creek
3. P1, P3, P7, P10, P8
4. Clear Creek and Small Tributaries
5. Clearwater Creek and Tributaries
6. Rush Creek
7. Drift Creek

These streams were selected based on EDT modeling described in Appendix C of the New Information Report (http://www.pacificorp.com/es/hydro/hl/lr.html#) showing that they produced the most spring Chinook if restored to Template. Additionally, at the December 16, 2016 subgroup meeting in Vancouver it was decided that for this round of modeling, habitat actions would not be considered in the Muddy River due to concerns about past and on-going effects of the Mt. St. Helens eruption (high sediment, mud flows etc.).

Table 2. Model assumptions by parameter for EDT model runs completed on January 18, 2017, January 19, 2017, and February 2, 2017.

	Model Run Date		
Parameter	**18-Jan**	**19-Jan**	**2-Feb**
Overall Downstream Survival (ODS)	80% All Alternatives	80% All Alternatives	75% (Alternatives 1A1, 1B, 2); 80% (Alternatives 1A2 and 3)
Juvenile Collection Efficiency (CE)	95%	95%	95%
Turbine/Spill Survival Rate for Swift No. 1 and Swift No.2, Respectively*	90%	90%	90%
Adult Trap Efficiency (ATE)	100%	100%	98%
Upstream Passage Survival (UPS)	100%	100%	99.5%
Spring Chinook, Coho and Steelhead Harvest Rates, Respectively	10%, 15%, 5%	10%, 15%, 5%	10%, 15%, 5%
Stream Habitat Restored to Template	Selected Tributaries Upstream of Swift (68.2 km, 42.4 miles)	Selected Tributaries and Mainstem Lewis River Upstream of Swift (67.5 km, 41.9 miles)	1) Both Tributaries and Mainstem Lewis River Upstream of Swift (91 km, 56.5 miles) 2) All of 1 plus 8.1 km (5 miles) of Mainstem Lewis Downstream of Merwin (total of 99 km, 61.5 miles).

*Turbine survival rate for Swift No.1 based on survival data collected at Mayfield Dam. Swift No.2 based on generic turbine survival rate for Columbia River mainstem dams equipped with Kaplan turbines.

Mainstem Lewis River reaches upstream of Swift were initially not selected for restoration given lack of detail on the feasibility and costs of actions before including them in the analysis. Subsequently the subgroup directed that the mainstem be included for the January 19, 2017 model runs. Finally, streams located within the Mt. St. Helens Monument were by law, off-limits to restoration work. Modeled streams and corresponding lengths are show below (Table 3).

The seven streams selected for restoration for the January 18, 2017 run have a combined length of 68.22 kilometers. Therefore, the assumption for modeling is that $37.954 million is sufficient to restore 68.22 kilometers of stream habitat to template condition, or $556,591 per kilometer of stream.

Table 3. Streams/reaches restored to Template conditions for the January 18, 2017, January 19, 2017, and February 2, 2017 EDT model runs.

18-Jan		19-Jan		Feb 2- Upstream of Swift Only		Feb-2 Upstream of Swift and Mainstem Lewis River Below Merwin
Stream/Reach	Length (km)	Stream/Reach	Length (km)	Stream/Reach	Length (km)	Length (km)
Clear Creek	9.9	Clear Creek	9.9	Clear Creek	9.9	9.9
Clear Creek Lower	9.9	Clear Creek Lower	9.9	Clear Creek Lower	9.9	9.9
Clear Creek Small Tribs	3.17	Lewis 18	1.13	Clear Creek Small Tribs	3.17	3.17
Clearwater Creek	8.37	Lewis 19	0.81	Clearwater Creek	8.37	8.37
Clearwater Tribs	1.29	Lewis 20	8.85	Clearwater Tribs	1.29	1.29
Drift Creek	1.52	Lewis 21	1.61	Drift Creek	1.52	1.52
Drift Creek Upper	1.07	Lewis 22	1.77	Drift Creek Upper	1.07	1.07
P1	1.45	Lewis 23	5.63	Lewis 18	1.13	1.13
P10	0.48	Lewis 24	0.64	Lewis 19	0.81	0.81
P3	1.61	Lewis 25	0.48	Lewis 20	8.85	8.85
P7	1.77	Lewis 26	1.45	Lewis 21	1.61	1.61
P8	6.76	Lewis 27	0.32	Lewis 22	1.77	1.77
Pine Creek 1	2.82	P1	1.45	Lewis 23	5.63	5.63
Pine Creek 2	0.81	P10	0.48	Lewis 24	0.64	0.64
Pine Creek 3	1.61	P3	1.61	Lewis 25	0.48	0.48
Pine Creek 4	1.61	P7	1.77	Lewis 26	1.45	1.45
Pine Creek 5	1.61	P8	6.76	Lewis 27	0.32	0.32
Pine Creek 6	4.43	Pine Creek 1	2.82	P1	1.45	1.45
Rush Creek	4.02	Pine Creek 2	0.81	P10	0.48	0.48
S15	2.09	Pine Creek 3	1.61	P3	1.61	1.61
Swift Campground Creek	1.93	Pine Creek 4	1.61	P7	1.77	1.77
		Pine Creek 5	1.61	P8	6.76	6.76
		Pine Creek 6	4.43	Pine Creek 1	2.82	2.82
				Pine Creek 2	0.81	0.81
				Pine Creek 3	1.61	1.61
				Pine Creek 4	1.61	1.61
				Pine Creek 5	1.61	1.61
				Pine Creek 6	4.43	4.43
				Rush Creek	4.02	4.02
				S15	2.09	2.09
				Swift Campground Creek	1.93	1.93
				Mainstem Lewis Below Merwin		8.1
Total January 18	**68.22**	**Total January 19**	**67.45**	**Total February 2**	**90.91**	**99.01**

The costs per kilometer for various habitat actions provided by Cramer are as follows (see New Information Regarding Fish Transport into Lake Merwin and Yale Lake ("New Information Report"), Appendix D, p. 25):

1. LWD Placement - $72,800 per kilometer. Based on this cost and kilometers of stream (68.22), the total cost to restore LWD to all analysis streams would be ~$5 million (under the assumption that every kilometer needs at least some treatment).
2. Riparian Placement - $4.82 per square meter. It would cost ~$19.72 million to restore 68.22 kilometers (30 meter buffer width) on both sides of the streams. Under these assumptions the cost per kilometer would be $289,200. Again, the cost estimate assumes that every kilometer needs treatment. However, based on the results of habitat surveys used to rate the EDT riparian attribute, only 5-25 percent of the total riparian habitat in the identified streams is in need of restoration. If this estimate is indeed accurate then only $986,000 to $4.93 million would be required for restoration of riparian habitat.
3. Side Channel Construction - $1.93 per square meter. Given the assumption that monies not spent on LWD and riparian improvement ($37.954 million - $5 million - $20 million = **$12.954 million**) would be spent on side-channel construction that would allow for development of 6.5 million square meters of this habitat type.

As shown in Table 4, the full $37.954 million is only available for Alternative 3. The other alternatives have less money for habitat actions as these alternatives include additional fish passage structures. The amount of stream habitat that is assumed restored under each alternative is based on the ratio of monies available by alternative divided by the total monies available (Table 4).

The streams selected for restoration in each alternative were based on spring Chinook production potential, as shown in the New Information Report, Appendix C - Tables 3.14-3.16. Thus, the highest producing stream was chosen 1st, followed by the 2nd and 3rd until the target number of kilometers for each alternative was achieved. Reach lengths could not be altered, thus the total amount of habitat restored in each alternative may have been slightly different than the target value.

EDT modeling was conducted for spring Chinook, coho and steelhead under two scenarios:

1. Alternatives modeled with fish passage actions only
2. Alternatives modeled with fish passage and habitat restoration.

A description of each model output (parameter) is provided in Table 5.

Table 4. Calculation of kilometers of stream habitat to target for restoration to Template for each analysis alternative.

Alternative	Habitat Fund	Fund Ratio (X)	Total Kilometers Habitat (Y)	Kilometers Habitat Restored (X*Y)
1A1	$25,303,000	66.7%	68.2	45.5
1A2	$25,303,000	66.7%	68.2	45.5
1B	$18,997,000	50.1%	68.2	34.2
2	$0	0%	68.2	0.0
3	$37,954,000	100%	68.2	68.2

Table 5. Definition of model outputs presented for each alternative.

Parameter	Definition
Abundance	The average number of adults or juveniles produced
Capacity	The maximum number of adults or juveniles the habitat can support
Spatial	The percent of the total spawning habitat available upstream of Merwin Dam that each species has access to by alternative. For example, because fish passage is provided at all three dams, fish have access to 100 percent of the spawning habitat in Alternative 2.
Productivity	Adult or juvenile recruits per spawners at low spawner abundance (i.e. absence of density dependence effects)
Diversity	The percent of all EDT life history trajectories that had a productivity of 1.0 or greater. The maximum possible score is 100 percent.
Extinction Risk	5 percent of all life cycle model runs that were below the identified value. The lower the value the higher the extinction risk.
EDT Template	The template condition in EDT represents the baseline condition from which current conditions are compared. For the Lewis River, template conditions for habitat upstream of Merwin reflect pre-development conditions with the exception that the dams and reservoirs are in place; resulting in the conversion of stream habitat to reservoir. Stream habitat attribute ratings in the Lewis River downstream of Merwin only approximate pre-development habitat conditions. For example, because data were not available to quantify total side-channel habitat, the amount of side-channel habitat was set at 15 percent based on a simple assumption that there should have been more of this habitat type prior to development. Flow attribute ratings for the lower Lewis River mainstem assumed that dams were removed. Habitat in the mainstem Columbia River was rated based on current conditions.

The total amount of spawning habitat available for spring Chinook, coho and steelhead upstream of Merwin Dam is provided in Table 6.

Table 6. Available spawning habitat by species for Merwin, Yale and Swift geographic areas.

Species	Kilometers Spawning Habitat
Total Spring Chinook	157.593
Yale Lake	14.249
Swift Reservoir	143.344
Total Coho salmon	186.922
Lake Merwin	9.485
Yale Lake	29.589
Swift Reservoir	147.848
Total Winter Steelhead	171.596
Lake Merwin	9.485
Yale Lake	29.589
Swift Reservoir	132.522

January 19, 2017 EDT Model Run

At the January 18, 2017 meeting, the ACC science subgroup asked that modelers look at substituting mainstem Lewis River upstream of Swift habitat for a similar amount of tributary habitat modeled on January 18, 2017. A list of streams/reaches modeled on January 19, 2017 is shown in Table 3. Because of time constraints (1-day turnaround) only alternatives 1A1, 1B and 3 were modeled. The same two scenarios described for the January 18, 2017 model runs were also run for this modeling effort.

February 2. 2017 EDT Model Run

The January 18, 2017 EDT model run assumed that ~$500,000 per kilometer of stream was sufficient to restore the relatively high quality stream habitat upstream of Swift Dam to Template conditions as defined by EDT. In conversations with Lower Columbia Recovery Board staff they were of the opinion that $500,000 per mile may be a better estimate of habitat restoration costs[2]. If this is the case then the $37.954 million dollars is sufficient to restore 75.9 miles of stream.

Based on the new habitat restoration assumptions, the EDT Model was run under two conditions:

1) Upstream of Swift Habitat Restoration- For this run all tributary and mainstem Lewis River habitat upstream of Swift defined previously (January 18 and 19, 2017) was restored to Template condition (Table 3). This resulted in 56.5 miles (90.91 kilometers) miles of habitat being restored at an assumed restoration cost of $28.235 million. This left approximately $9.7 million that could be used as a reserve fund or spent on improving additional habitat.

2) Addition of Mainstem Lewis River Habitat Downstream of Merwin Dam - In this model run, the remaining ~$9.7 million was assumed spent on restoring an additional 5 miles (8.1 km) of stream habitat in the mainstem Lewis River downstream of Merwin Dam. This equates to a cost per mile of $1.9 million. A larger cost per mile was assumed due to the size of the river reaches in the

[2] The $500,000 per mile value was based on the average amount of monies per mile requested by project sponsors in the Lower Columbia River. Therefore, the monies do not necessarily restore habitat conditions to the EDT template condition as this was not the purpose of the projects submitted.

mainstem Lewis River and the fact that there would be additional costs associated with land purchases/easements. Mainstem habitat was selected for restoration as it provided benefits to all species. The reaches restored were Lewis 1 Tidal A/B and Lewis 2 Tidal B. The total amount of habitat restored for this run was 61.5 miles (99.01 km).

At the February 2, 2017 science subgroup meeting, attendees expressed concern that $9.1 million may be insufficient to restore lower Lewis River mainstem reaches to EDT Template. Although a formal effort and cost analysis has not been conducted, it is noted that Cramer (Appendix D of the New Information Report (2016)) estimated that the costs of implementing side-channel, LWD and riparian restorations actions in Lewis 1 Tidal A and Lewis 2 Tidal B would be $2.6 million and $2.1 million respectively. This equates to a cost per mile of $1.35 million[3] compared to the EDT assumption of $1.9 million. Additionally, in the EDT analysis it was assumed that all riparian habitat needed treatment. The total cost for riparian treatment for 61.5 miles of stream habitat is $28.63 million. Based on EDT riparian ratings (5-25% of reaches need treatment) the actual cost may be less than $7.2 million.

Note that the benefits habitat improvements in the mainstem Lewis River may have on lower Lewis River and North Fork Lewis River fish populations were not analyzed. It was also assumed that restoring habitat in tributaries upstream of Swift Dam had no effect on downstream habitat conditions, including the Muddy River; where many of the smaller restored tributaries streams flowed into. As mainstem habitat such as the Muddy River reflect habitat conditions in its tributaries, some improvement in habitat conditions in the Muddy River is likely.

An extinction risk analysis was not performed for this set of runs. Previous model outputs showed little extinction risk due to high population productivity and adult abundance for each species and alternative.

Because of concerns that juvenile mortality due to predation by other species may be higher in Merwin Reservoir than assumed in EDT, a predation analysis was conducted by running a simple population model with no variability using productivity and capacity values for Merwin Coho and steelhead derived from the EDT analysis.

EDT Model Results

January 18, 2017 EDT Model Runs

EDT model results for January 18, 2017 are presented in Table 7 (Passage Only) and Table 8 (Passage + Habitat).

January 19, 2017 EDT Model Runs

EDT model results for January 19, 2017 are presented in Table 9 (Passage Only) and Table 10 (Passage + Habitat)

[3] These values do not include land acquisition and design.

February 2, 2017 EDT Model Runs

EDT model results for February 2, 2017 are presented in Table 11 (Upstream of Swift) and Table 12 (Upstream of Swift + Mainstem Lewis Habitat Downstream of Merwin). A summary of fish production for the Merwin, Swift and Yale geographic areas for each model run is presented in Appendix B. Note that in the Appendix B tables' total adult abundance for an alternative may not be equal to the sum of the individual populations (geographic areas). This difference in adult abundance results from differences in productivity and capacity between populations, which when combined into a single population results in a small difference in abundance.

The results of increasing predation losses on juveniles migrating/rearing in Merwin Reservoir are presented in Table 13.

Table 7. January 18, 2017 EDT model run for Fish Passage Only. No habitat restoration actions are included in the alternatives. The cells highlighted in green delineate the best performing alternative for a given population parameter.

	All Species Combined															
	Spring Chinook				Coho				Winter Steelhead					Extinction Threshold		
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance	S. Chin.	Coho	W. Sthd
1A1	3,309	100%	5.48	80%	9,969	95%	6.9	76%	2,252	94%	11.82	76%	15,531	1,241	1,879	968
1A2	3,024	91%	5.69	79%	8,680	79%	7.1	81%	1,917	77%	12.60	78%	13,621	1,247	2,709	799
1B	3,266	100%	5.11	80%	9,880	95%	5.7	78%	2,112	94%	11.17	77%	15,257	1,418	2,037	947
2	2,979	100%	5.08	77%	9,132	100%	5.5	70%	2,063	100%	9.14	75%	14,174	1,136	1,630	916
3	3,120	91%	6.11	78%	9,431	79%	7.6	79%	1,946	77%	13.50	77%	14,497	1,252	2,848	849

Percent Difference Between Alternatives and Alternative 2 (Full Passage No Habitat)

	Spring Chinook				Coho				Winter Steelhead					Extinction Threshold		
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance	S. Chin.	Coho	W. Sthd
1A1	11%	0%	8%	5%	9%	-5%	26%	8%	9%	-6%	29%	2%	10%	9%	15%	6%
1A2	2%	-9%	12%	2%	-5%	-21%	28%	15%	-7%	-23%	38%	5%	-4%	10%	66%	-13%
1B	10%	0%	1%	4%	8%	-5%	4%	11%	2%	-6%	22%	4%	8%	25%	25%	3%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	5%	-9%	20%	1%	3%	-21%	38%	12%	-6%	-23%	48%	3%	2%	10%	75%	-7%

Parameter	Model Run Assumptions 18-Jan
Overall Downstream Survival (ODS)	80% All Alternatives
Juvenile Collection Efficiency (CE)	95%
Turbine/Spill Survival Rate for Swift No. 1 and Swift No.2, Respectively*	90%
Adult Trap Efficiency (ATE)	100%
Upstream Passage Survival (UPS)	100%
Spring Chinook, Coho and Steelhead Harvest Rates, Respectively	10%, 15%, 5%
Stream Habitat Restored to Template	

Table 8. January 18, 2017 EDT model run for Fish Passage and Habitat. The cells highlighted in green delineate the best performing alternative for a given population parameter.

	All Species Combined																
	Spring Chinook				Coho				Winter Steelhead					Extinction Threshold		
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance	S. Chin.	Coho	W. Sthd
1A1	3,309	100%	5.48	80%	9,969	95%	6.9	76%	2,252	94%	11.82	76%	15,531	1,241	1,879	968
1A2	3,024	91%	5.69	79%	8,680	79%	7.1	81%	1,917	77%	12.60	78%	13,621	1,247	2,709	799
1B	3,266	100%	5.11	80%	9,880	95%	5.7	78%	2,112	94%	11.17	77%	15,257	1,418	2,037	947
2	2,979	100%	5.08	77%	9,132	100%	5.5	70%	2,063	100%	9.14	75%	14,174	1,136	1,630	916
3	3,120	91%	6.11	78%	9,431	79%	7.6	79%	1,946	77%	13.50	77%	14,497	1,252	2,848	849

Percent Difference Between Alternatives and Alternative 2 (Full Passage No Habitat)

	Spring Chinook				Coho				Winter Steelhead					Extinction Threshold		
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance	S. Chin.	Coho	W. Sthd
1A1	11%	0%	8%	5%	9%	-5%	26%	8%	9%	-6%	29%	2%	10%	9%	15%	6%
1A2	2%	-9%	12%	2%	-5%	-21%	28%	15%	-7%	-23%	38%	5%	-4%	10%	66%	-13%
1B	10%	0%	1%	4%	8%	-5%	4%	11%	2%	-6%	22%	4%	8%	25%	25%	3%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	5%	-9%	20%	1%	3%	-21%	38%	12%	-6%	-23%	48%	3%	2%	10%	75%	-7%

Parameter	Model Run Assumptions 18-Jan
Overall Downstream Survival (ODS)	80% All Alternatives
Juvenile Collection Efficiency (CE)	95%
Turbine/Spill Survival Rate for Swift No. 1 and Swift No.2, Respectively*	90%
Adult Trap Efficiency (ATE)	100%
Upstream Passage Survival (UPS)	100%
Spring Chinook, Coho and Steelhead Harvest Rates, Respectively	10%, 15%, 5%
Stream Habitat Restored to Template	Selected Tributaries Upstream of Swift (68.2 km, 42.4 miles)

Table 9. January 19, 2017 EDT model run for Fish Passage Only. No habitat restoration actions are included the alternatives. The cells highlighted in green delineate the best performing alternative for a given population parameter.

	All Species Combined															
	Spring Chinook				Coho				Winter Steelhead					Extinction Threshold		
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance	S. Chin.	Coho	W. Sthd
1A1	2,929	100%	5.04	78%	8,564	95%	5.55	71%	1,967	94%	9.36	75%	13,460	1,064	1,461	845
1A2	2,649	91%	5.24	75%	7,356	79%	5.60	74%	1,645	77%	9.82	76%	11,650	1,109	2,266	740
1B	2,916	100%	4.81	77%	8,919	95%	5.16	72%	1,862	94%	9.04	75%	13,697	1,257	1,770	839
2	2,979	100%	5.08	77%	9,132	100%	5.52	70%	2,063	100%	9.14	75%	14,174	1,178	1,652	909
3	2,560	91%	5.27	73%	7,330	79%	5.65	71%	1,589	77%	9.87	73%	11,480	1,059	2,190	707

Percent Difference Between Alternatives and Alternative 2 (Full Passage No Habitat)

	Spring Chinook				Coho				Winter Steelhead					Extinction Threshold		
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance	S. Chin.	Coho	W. Sthd
1A1	-2%	0%	-1%	1%	-6%	-5%	1%	1%	-5%	-6%	2%	0%	-5%	-10%	-12%	-7%
1A2	-11%	-9%	3%	-2%	-19%	-21%	1%	5%	-20%	-23%	7%	2%	-18%	-6%	37%	-19%
1B	-2%	0%	-5%	0%	-2%	-5%	-6%	3%	-10%	-6%	-1%	1%	-3%	7%	7%	-8%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	-14%	-9%	4%	-6%	-20%	-21%	2%	1%	-23%	-23%	8%	-2%	-19%	-10%	33%	-22%

Parameter	Model Run Assumptions 19-Jan
Overall Downstream Survival (ODS)	80% All Alternatives
Juvenile Collection Efficiency (CE)	95%
Turbine/Spill Survival Rate for Swift No. 1 and Swift No.2, Respectively*	90%
Adult Trap Efficiency (ATE)	100%
Upstream Passage Survival (UPS)	100%
Spring Chinook, Coho and Steelhead Harvest Rates, Respectively	10%, 15%, 5%
Stream Habitat Restored to Template	

Table 10. January 19, 2017 EDT model run for Fish Passage and Habitat. The cells highlighted in green delineate the best performing alternative for a given population parameter.

	All Species Combined															
	Spring Chinook				Coho				Winter Steelhead					Extinction Threshold		
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance	S. Chin.	Coho	W. Sthd
1A1	3,309	100%	5.48	80%	9,969	95%	6.9	76%	2,252	94%	11.82	76%	15,531	1,241	1,879	968
1A2	3,024	91%	5.69	79%	8,680	79%	7.1	81%	1,917	77%	12.60	78%	13,621	1,247	2,709	799
1B	3,266	100%	5.11	80%	9,880	95%	5.7	78%	2,112	94%	11.17	77%	15,257	1,418	2,037	947
2	2,979	100%	5.08	77%	9,132	100%	5.5	70%	2,063	100%	9.14	75%	14,174	1,136	1,630	916
3	3,120	91%	6.11	78%	9,431	79%	7.6	79%	1,946	77%	13.50	77%	14,497	1,252	2,848	849

Percent Difference Between Alternatives and Alternative 2 (Full Passage No Habitat)

	Spring Chinook				Coho				Winter Steelhead					Extinction Threshold		
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance	S. Chin.	Coho	W. Sthd
1A1	11%	0%	8%	5%	9%	-5%	26%	8%	9%	-6%	29%	2%	10%	9%	15%	6%
1A2	2%	-9%	12%	2%	-5%	-21%	28%	15%	-7%	-23%	38%	5%	-4%	10%	66%	-13%
1B	10%	0%	1%	4%	8%	-5%	4%	11%	2%	-6%	22%	4%	8%	25%	25%	3%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	5%	-9%	20%	1%	3%	-21%	38%	12%	-6%	-23%	48%	3%	2%	10%	75%	-7%
	All Species Combined															

Parameter	Model Run Assumptions 19-Jan
Overall Downstream Survival (ODS)	80% All Alternatives
Juvenile Collection Efficiency (CE)	95%
Turbine/Spill Survival Rate for Swift No. 1 and Swift No.2, Respectively*	90%
Adult Trap Efficiency (ATE)	100%
Upstream Passage Survival (UPS)	100%
Spring Chinook, Coho and Steelhead Harvest Rates, Respectively	10%, 15%, 5%
Stream Habitat Restored to Template	Selected Tributaries and Mainstem Lewis River Upstream of Swift (67.5 km, 41.9 miles)

Table 11. February 2, 2017 EDT model run for Upstream of Swift Fish Passage and Habitat. The cells highlighted in green delineate the best performing alternative for a given population parameter.

	All Species Combined												
	Spring Chinook				Coho				Winter Steelhead				
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance
1A1	3,375	100%	5.48	81%	9,480	95%	6.1	79%	2,230	94%	11.69	77%	15,086
1A2	3,298	91%	6.05	81%	8,899	79%	6.5	85%	2,011	77%	13.25	81%	14,208
1B	3,279	100%	5.17	80%	9,582	95%	5.5	80%	2,049	94%	11.09	78%	14,911
2	2,800	100%	4.83	75%	8,445	100%	5.2	69%	1,943	100%	8.64	73%	13,188
3	3,184	91%	6.09	77%	8,869	79%	6.6	81%	1,943	77%	13.34	77%	13,996

Percent Difference Between Alternatives and Alternative 2 (Full Passage No Habitat)

	Spring Chinook				Coho				Winter Steelhead				
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance
1A1	21%	0%	14%	8%	12%	-5%	17%	13%	15%	-6%	35%	5%	14%
1A2	18%	-9%	25%	8%	5%	-21%	25%	22%	4%	-23%	53%	10%	8%
1B	17%	0%	7%	7%	13%	-5%	6%	16%	5%	-6%	28%	7%	13%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	14%	-9%	26%	4%	5%	-21%	26%	17%	0%	-23%	54%	6%	6%

Parameter	Model Run Assumptions 2-Feb
Overall Downstream Survival (ODS)	75% (Alternatives 1A1, 1B, 2); 80% (Alternatives 1A2 and 3)
Juvenile Collection Efficiency (CE)	95%
Turbine/Spill Survival Rate for Swift No. 1 and Swift No.2, Respectively*	90%
Adult Trap Efficiency (ATE)	98%
Upstream Passage Survival (UPS)	99.50%
Spring Chinook, Coho and Steelhead Harvest Rates, Respectively	10%, 15%, 5%
Stream Habitat Restored to Template	1) Both Tributaries and Mainstem Lewis River Upstream of Swift (91 km, 56.5 miles)

Table 12. February 2, 2017 EDT model run for Upstream of Swift + Mainstem Lewis Downstream of Merwin Dam Fish Passage and Habitat. The cells highlighted in green delineate the best performing alternative for a given population parameter.

	All Species Combined												
	Spring Chinook				Coho				Winter Steelhead				
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance
1A1	3,752	100%	5.76	86%	11,878	95%	7.6	80%	2,437	94%	12.81	82%	18,067
1A2	3,686	91%	6.40	86%	11,121	79%	8.2	86%	2,210	77%	14.51	85%	17,017
1B	3,532	100%	5.43	85%	11,011	95%	6.6	81%	2,196	94%	12.03	80%	16,739
2	2,800	100%	4.83	75%	8,445	100%	5.2	69%	1,943	100%	8.64	73%	13,188
3	3,911	91%	6.38	89%	12,153	79%	8.8	88%	2,280	77%	15.51	87%	18,344

Percent Difference Between Alternatives and Alternative 2 (Full Passage No Habitat)

	Spring Chinook				Coho				Winter Steelhead				
Alternative	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Abundance	Spatial	Productivity	Diversity	Total Abundance
1A1	34%	0%	19%	15%	41%	-5%	46%	15%	25%	-6%	48%	12%	37%
1A2	32%	-9%	33%	15%	32%	-21%	57%	23%	14%	-23%	68%	16%	29%
1B	26%	0%	13%	13%	30%	-5%	27%	17%	13%	-6%	39%	9%	27%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	40%	-9%	32%	19%	44%	-21%	68%	27%	17%	-23%	79%	19%	39%

Parameter	Model Run Assumptions 2-Feb
Overall Downstream Survival (ODS)	75% (Alternatives 1A1, 1B, 2); 80% (Alternatives 1A2 and 3)
Juvenile Collection Efficiency (CE)	95%
Turbine/Spill Survival Rate for Swift No. 1 and Swift No.2, Respectively*	90%
Adult Trap Efficiency (ATE)	98%
Upstream Passage Survival (UPS)	99.50%
Spring Chinook, Coho and Steelhead Harvest Rates, Respectively	10%, 15%, 5%
Stream Habitat Restored to Template	1) Both Tributaries and Mainstem Lewis River Upstream of Swift (91 km, 56.5 miles) 2) All of 1 plus 8.1 km (5 miles) of Mainstem Lewis Below Merwin (total of 99 km, 61.5 miles).

Table 13. February 2, 2017 predation analysis for Coho and Steelhead populations associated with Merwin geographic area. Productivity and abundance values are based on EDT analyses (Appendix B).

	Coho			Steelhead		
Percent Increase Predation	**Adult Productivity**	**Adult Abundance**	**Percent Change in Adult Abundance From EDT Baseline**	**Adult Productivity**	**Adult Abundance**	**Percent Change in Adult Abundance From EDT Baseline**
EDT Baseline	4.70	447	0.00%	5.00	66	0.00%
5%	4.47	419	-6.3%	4.75	62	-6.1%
10%	4.23	390	-12.8%	4.50	57	-13.6%
15%	4.00	362	-19.0%	4.25	53	-19.7%
20%	3.76	334	-25.3%	4.00	49	-25.8%
25%	3.53	305	-31.8%	3.75	45	-31.8%
30%	3.29	277	-38.0%	3.50	41	-37.9%
40%	2.82	220	-50.8%	3.25	33	-50.0%
50%	2.35	163	-63.5%	2.50	25	-62.1%

Appendix A: Description of Alternatives

Description of Alternatives

For all the following alternatives, the Merwin Upstream Collection Facility and the Swift Floating Surface Collector (FSC) will continue to operate through the life of the license.

Alternative 1A1 – This scenario only includes a downstream floating surface collector near Yale dam. Adult fish are collected at the Merwin Upstream Collection Facility and a portion of the adults (TBD) are taken and released into Yale reservoir. The remainder of the adults are transported upstream of Swift dam. Progeny produced by adults in tributaries to Yale Lake and that enter the Yale floating surface collector will be uniquely marked then transported to the Woodland Release ponds for release into the lower Lewis River. When those fish return as adults or jacks to the Merwin Upstream Collection Facility, they will be transported and released in accordance with a yet to be developed management plan aligned with recovery goals (e.g. connectivity to support gene flow).

Alternative 1A2 – In this scenario, a downstream floating surface collector will be constructed and put into operation at Yale dam but no adults will be purposefully transported to Yale Lake. All adult upstream migrants collected at the Merwin Upstream Collection Facility will be transported and released upstream of Swift dam. The primary purpose of the Yale FSC will be to collect any downstream migrants that may have passed through the Swift exclusion netting at the Swift FSC, then through the turbines at Swift No. 1 and Swift No. 2 or through spill at Swift dam and into Yale Lake. Downstream migrating juveniles will not need to be uniquely marked.

Alternative 1B – For this scenario, all adults and jacks collected at the Merwin Upstream Collection Facility are taken to Yale Lake and released. Facilities include a downstream floating surface collector near Yale dam and an adult collection and sorting facility near either Swift No.1 dam or the Swift No. 2 power canal. The adults have the choice of either remaining in Yale Lake or tributaries to spawn or migrate to the upstream collection and sorting facility to be transported upstream of Swift dam. Downstream migrating juveniles will not need to be uniquely marked.

Alternative 2 – Downstream FSCs will be constructed in Yale Lake and Lake Merwin near the dams and upstream collection and sorting facilities will be constructed at the Yale tailrace and either Swift No. 1 dam or the Swift No. 2 power canal. All upstream migrants will be transported to Lake Merwin from the Merwin Upstream Collection Facility and adults will have the choice to either stay in Lake Merwin or move upstream to the Yale Upstream Collection and Sorting Facility. Adults and jacks collected at the Yale facility will be transported upstream into Yale Lake. Fish can either choose to remain in Yale Lake or continue upstream to the Swift Upstream Collection and Sorting Facility where upon collection, they will be transported upstream of Swift dam and allowed to spawn where they choose. Downstream migrants that enter any of the FSCs will be transported to the Woodland Release Ponds downstream of Merwin. Downstream migrating juveniles will not need to be uniquely marked.

Alternative 3 – Downstream passage facilities are not constructed at Yale or Merwin dams and upstream passage is not provided at Yale tailrace or either Swift No. 1 dam or the Swift No. 2 power canal. Upstream fish passage remains at Merwin dam and downstream fish passage remains at Swift reservoir only.

Appendix B

February 2, 2017 EDT Results by Species and Geographic Area

Table B-1. February 2, 2017 EDT results for Merwin, Yale and Swift geographic areas. Habitat Restored Upstream of Swift Only.

	Adult				Juvenile		
Alternative 1A1	**Diversity**	**Productivity**	**Capacity**	**Abundance**	**Productivity**	**Capacity**	**Abundance**
	Spring Chinook						
Total	80.6%	5.5	4,128	3,375	430	797,223	514,448
Yale Lake	97.5%	3.7	373	274	586	124,283	70,020
Swift Reservoir	78.9%	5.7	3,755	3,092	413	672,941	440,819
	Coho						
Total	78.7%	6.1	11,343	9,480	177	963,910	612,408
Yale Lake	50.2%	4.0	1,544	1,154	289	463,484	193,902
Swift Reservoir	84.5%	6.3	9,738	8,188	168	492,244	362,490
	Winter Steelhead						
Total	77.4%	11.7	2,439	2,230	192	59,485	52,232
Yale Lake	64.6%	6.9	324	277	128	8,748	7,012
Swift Reservoir	80.3%	12.4	2,110	1,939	201	50,607	44,792
Alternative 1A2	**Diversity**	**Productivity**	**Capacity**	**Abundance**	**Productivity**	**Capacity**	**Abundance**
	Spring Chinook						
Total	80.5%	6.0	3,951	3,298	436	695,860	469,059
Swift Reservoir	80.5%	6.0	3,951	3,298	436	695,860	469,059
Coho	**Coho**						
Total	84.7%	6.5	10,517	8,899	173	512,845	384,971
Swift Reservoir	84.7%	6.5	10,517	8,899	173	512,845	384,971
	Winter Steelhead						
Total	80.9%	13.3	2,176	2,011	215	51,834	46,275
Swift Reservoir	80.9%	13.3	2,176	2,011	215	51,834	46,275
Alternative 1B	**Diversity**	**Productivity**	**Capacity**	**Abundance**	**Productivity**	**Capacity**	**Abundance**
	Spring Chinook						
Total	79.6%	5.2	4,066	3,279	372	641,287	420,494
Yale Lake	98.3%	3.6	368	266	562	119,210	66,262
Swift Reservoir	77.8%	5.3	3,698	3,004	353	522,077	349,987
	Coho						
Total	80.5%	5.5	11,712	9,582	153	870,639	546,665
Yale Lake	49.9%	4.0	1,521	1,145	300	505,004	204,211
Swift Reservoir	86.5%	5.6	10,116	8,318	142	359,575	275,454
	Winter Steelhead						
Total	78.4%	11.1	2,252	2,049	179	51,338	45,024
Yale Lake	65.3%	6.8	327	279	124	8,630	6,908
Swift Reservoir	81.1%	11.7	1,918	1,754	187	42,486	37,610
Alternative 2	**Diversity**	**Productivity**	**Capacity**	**Abundance**	**Productivity**	**Capacity**	**Abundance**
	Spring Chinook						
Total	74.7%	4.8	3531	2800	348	635,293	384,697
Yale Lake	98.0%	3.6	365	263	586	123,348	68,578
Swift Reservoir	72.4%	5.0	3,166	2,531	318	511,945	313,091
	Coho						
Total	69.5%	5.2	10,450	8,445	153	867,594	518,426
Merwin	68.0%	4.7	568	447	141	31,360	20,918
Yale Lake	48.4%	4.0	1,559	1,167	268	424,538	180,236
Swift Reservoir	73.7%	5.4	8,322	6,770	142	411,697	288,157
	Winter Steelhead						
Total	73.4%	8.6	2,197	1,943	144	51,206	43,270
Merwin	68.5%	5.0	82	66	94	1,941	1,479
Yale Lake	65.6%	6.7	330	281	122	8,626	6,894
Swift Reservoir	75.3%	9.2	1,777	1,583	150	40,414	34,526
Alternative 3	**Diversity**	**Productivity**	**Capacity**	**Abundance**	**Productivity**	**Capacity**	**Abundance**
	Spring Chinook						
Total	77.4%	6.1	3,810	3,184	442	682,103	459,575
Swift Reservoir	77.4%	6.1	3,810	3,184	442	682,103	459,575
	Coho						
Total	81.4%	6.6	10,462	8,869	176	523,887	392,213
Swift Reservoir	81.4%	6.6	10,462	8,869	176	523,887	392,213
	Winter Steelhead						
Total	77.4%	13.3	2,100	1,943	217	50,471	45,073
Swift Reservoir	77.4%	13.3	2,100	1,943	217	50,471	45,073

Table B-2. February 2, 2017 EDT results for Merwin, Yale and Swift geographic areas. Habitat Restored Upstream of Swift and Mainstem Lewis Downstream of Merwin.

	Adult				Juvenile		
Alternative 1A1	**Diversity**	**Productivity**	**Capacity**	**Abundance**	**Productivity**	**Capacity**	**Abundance**
	Spring Chinook						
Total	85.8%	5.8	4,541	3,752	447	888,465	580,932
Yale Lake	98.0%	3.9	388	288	604	129,948	74,364
Swift Reservoir	84.5%	5.9	4,152	3,453	433	758,516	503,113
	Coho						
Total	79.8%	7.6	13,681	11,878	209	1,005,894	716,191
Yale Lake	50.6%	4.8	1,792	1,417	282	443,251	210,248
Swift Reservoir	85.8%	7.8	11,827	10,315	204	553,799	438,448
	Winter Steelhead						
Total	82.1%	12.8	2,643	2,437	209	64,710	57,401
Yale Lake	68.1%	6.9	336	288	128	9,001	7,232
Swift Reservoir	85.3%	13.5	2,301	2,131	219	55,576	49,654
Alternative 1A2	**Diversity**	**Productivity**	**Capacity**	**Abundance**	**Productivity**	**Capacity**	**Abundance**
	Spring Chinook						
Total	85.9%	6.4	4,368	3,686	457	786,586	536,183
Swift Reservoir	85.9%	6.4	4,368	3,686	457	786,586	536,183
Coho	**Coho**						
Total	85.7%	8.2	12,670	11,121	213	574,002	462,102
Swift Reservoir	85.7%	8.2	12,670	11,121	213	574,002	462,102
	Winter Steelhead						
Total	85.4%	14.5	2,374	2,210	232	56,819	51,158
Swift Reservoir	85.4%	14.5	2,374	2,210	232	56,819	51,158
Alternative 1B	**Diversity**	**Productivity**	**Capacity**	**Abundance**	**Productivity**	**Capacity**	**Abundance**
	Spring Chinook						
Total	84.8%	5.4	4,329	3,532	378	681,845	451,245
Yale Lake	98.3%	3.6	368	266	562	119,210	66,264
Swift Reservoir	83.5%	5.6	3,961	3,252	362	562,635	380,701
	Coho						
Total	81.1%	6.6	12,976	11,011	175	907,379	617,164
Yale Lake	49.9%	4.0	1,521	1,145	300	505,004	204,211
Swift Reservoir	87.2%	6.8	11,380	9,702	167	396,314	318,552
	Winter Steelhead						
Total	80.3%	12.0	2,395	2,196	192	54,832	48,510
Yale Lake	65.3%	6.8	327	279	124	8,630	6,908
Swift Reservoir	83.4%	12.7	2,061	1,899	201	45,980	41,026
Alternative 2	**Diversity**	**Productivity**	**Capacity**	**Abundance**	**Productivity**	**Capacity**	**Abundance**
	Spring Chinook						
Total	74.7%	4.8	3531	2800	348	635,293	384,697
Yale Lake	98.0%	3.6	365	263	586	123,348	68,578
Swift Reservoir	72.4%	5.0	3,166	2,531	318	511,945	313,091
	Coho						
Total	69.5%	5.2	10,450	8,445	153	867,594	518,426
Merwin	68.0%	4.7	568	447	141	31,360	20,918
Yale Lake	48.4%	4.0	1,559	1,167	268	424,538	180,236
Swift Reservoir	73.7%	5.4	8,322	6,770	142	411,697	288,157
	Winter Steelhead						
Total	73.4%	8.6	2,197	1,943	144	51,206	43,270
Merwin	68.5%	5.0	82	66	94	1,941	1,479
Yale Lake	65.6%	6.7	330	281	122	8,626	6,894
Swift Reservoir	75.3%	9.2	1,777	1,583	150	40,414	34,526
Alternative 3	**Diversity**	**Productivity**	**Capacity**	**Abundance**	**Productivity**	**Capacity**	**Abundance**
	Spring Chinook						
Total	88.8%	6.4	4,638	3,911	474	851,209	583,416
Swift Reservoir	88.8%	6.4	4,638	3,911	474	851,209	583,416
	Coho						
Total	88.4%	8.8	13,720	12,153	233	636,032	519,327
Swift Reservoir	88.4%	8.8	13,720	12,153	233	636,032	519,327
	Winter Steelhead						
Total	87.0%	15.5	2,437	2,280	247	58,479	52,983
Swift Reservoir	87.0%	15.5	2,437	2,280	247	58,479	52,983